

## CLAIMS

What is claimed is:

- 1 1. A roller cone drill bit comprising:  
2 a plurality of arms;  
3 rotatable cutting structures mounted on respective ones of said  
4 arms; and  
5 a plurality of teeth located on each of said cutting structures;  
6 wherein approximately the same axial force is acting on each of  
7 said cutting structure.
- 1 2. The roller cone drill bit of Claim 1, wherein the axial force on each  
2 of said cutting structure is between thirty-one (31) percent and  
3 thirty-five (35) percent of the total of the axial force on the bit.
- 1 3. A roller cone drill bit comprising:  
2 a plurality of arms;  
3 rotatable cutting structures mounted on respective ones of said  
4 arms; and  
5 a plurality of teeth located on each of said cutting structures;  
6 wherein a substantially equal volume of formation is drilled by each  
7 said cutting structure.
- 1 4. The roller cone drill bit of Claim 3, wherein the volume of  
2 formation drilled by each of said cutting structures is between  
3 thirty-one (31) percent and thirty-five (35) percent of the total  
4 volume drilled by the drill bit.

1 5. A rotary drilling system, comprising:  
2 a drill string which is connected to conduct drilling fluid from a  
3 -- surface location to a rotary drill bit;  
4 a rotary drive which rotates at least part of said drill string together  
5 with said bit  
6 said rotary drill bit comprising  
7 a plurality of arms;  
8 rotatable cutting structures mounted on respective ones of said  
9 arms; and  
10 a plurality of teeth located on each of said cutting structures;  
11 wherein approximately the same axial force is acting on each of  
12 said cutting structure.

1 6. A method of designing a roller cone drill bit, comprising the steps  
2 of:  
3 (a) calculating the volume of formation cut by each tooth on each  
4 cutting structure;  
5 (b) calculating the volume of formation cut by each cutting structure  
6 per revolution of the drill bit;  
7 (c) comparing the volume of formation cut by each of said cutting  
8 structures with the volume of formation cut by all others of  
9 said cutting structures of the bit;  
10 (d) adjusting at least one geometric parameter on the design of at  
11 least one cutting structure; and  
12 (e) repeating steps (a) through (d) until substantially the same  
13 volume of formation is cut by each of said cutting structures  
14 of said bit.

1 7. The method of Claim 6, wherein the step of calculating the volume  
2 of formation cut by each tooth on each cutting structure further  
3 comprises the step of using numerical simulation to determine  
4 the interval progression of each tooth as it intersects the  
5 formation.

1 8. A method of designing a roller cone drill bit, the steps of  
2 comprising:

3 (a) calculating the axial force acting on each tooth on each cutting  
4 structure;

5 (b) calculating the axial force acting on each cutting structure per  
6 revolution of the drill bit;

7 (c) comparing the axial force acting on each of said cutting  
8 structures with the axial force on the other ones of said  
9 cutting structures of the bit;

10 (d) adjusting at least one geometric parameter on the design of at  
11 least one cutting structure;

12 (e) repeating steps (a) through (d) until approximately the same  
13 axial force is acting on each cutting structure.

1 9. The method of Claim 8, wherein the step of calculating the normal  
2 force acting on each tooth, on each cutting structure further  
3 comprises the step of using numerical simulation to determine  
4 the interval progression of each tooth as it intersects the  
5 formation.

1 10. The method of Claim 8, further comprising the steps of:  
2 (a) calculating the volume of formation displaced by the depth of  
3 - - penetration of each tooth;  
4 (b) calculating the volume of formation displaced by the tangential  
5 scrapping movement of each tooth;  
6 (c) calculating the volume of formation displaced by the radial  
7 scrapping movement of each tooth; and,  
8 (d) calculating the volume of formation displaced by a crater  
9 enlargement parameter function.

1 11. A method of designing a roller cone drill bit, the steps of  
2 comprising:  
3 (a) calculating the force balance conditions of a bit;  
4 (b) defining design variables;  
5 (c) determine lower and upper bounds for the design variables;  
6 (d) defining objective functions;  
7 (e) defining constraint functions;  
8 (f) performing an optimization means; and,  
9 (g) evaluating an optimized cutting structure by modeling.

1 12. A method of using a roller cone drill bit, comprising the step of  
2 rotating said roller cone drill bit such that substantially the same  
3 volume of formation is cut by each roller cone of said bit.

1 13. A method of using a roller cone drill bit, comprising the step of  
2 rotating said roller cone drill bit such that substantially the same  
3 axial force is acting on each roller cone of said bit.